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To cite this article: Urmimala Sarkar , Andrew J. Karter , Jennifer Y. Liu , Nancy E. Adler , Robert Nguyen , Andrea López & Dean Schillinger (2010) The Literacy Divide: Health Literacy and the Use of an Internet-Based Patient Portal in an Integrated Health System—Results from the Diabetes Study of Northern California (DISTANCE), Journal of Health Communication, 15:S2, 183-196, DOI: [10.1080/10810730.2010.499988](https://doi.org/10.1080/10810730.2010.499988)

To link to this article: <https://doi.org/10.1080/10810730.2010.499988>



Published online: 15 Sep 2010.



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The Literacy Divide: Health Literacy and the Use of an Internet-Based Patient Portal in an Integrated Health System—Results from the Diabetes Study of Northern California (DISTANCE)

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Funds were provided by National Institute of Diabetes, Digestive and Kidney Diseases (R01 DK65664), and National Institute of Child Health and Human Development (R01 HD046113). This work was also supported by the National Center for Research Resources (KL2 RR024130). Dr. Sarkar is supported by Agency for Healthcare Research and Quality (K08 HS017594). Dr. Schillinger is supported by a grant from Agency for Healthcare Research and Quality (R18 HS01726101) and a NIH Clinical and Translational Science Award (ULRR024131). None of the funders had any role in design and conduct of the study; collection, management, analysis, or interpretation of the data; or preparation, review, or approval of the manuscript.

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Internet-based patient portals are intended to improve access and quality, and will play an increasingly important role in health care, especially for diabetes and other chronic diseases. Diabetes patients with limited health literacy have worse health outcomes, and limited health literacy may be a barrier to effectively utilizing internet-based health access services. We investigated use of an internet-based patient portal among a well characterized population of adults with diabetes. We estimated health literacy using three validated self-report items. We explored the independent association between health literacy and use of the internet-based patient portal, adjusted for age, gender, race/ethnicity, educational attainment, and income. Among 14,102 participants (28% non-Hispanic White, 14% Latino, 21% African-American, 9% Asian, 12% Filipino, and 17% multiracial or other ethnicity), 6099 (62%) reported some limitation in health literacy, and 5671 (40%) respondents completed registration for the patient portal registration. In adjusted analyses, those with limited health literacy had higher odds of never signing on to the patient portal (OR 1.7, 1.4 to 1.9) compared with those who did not report any health literacy limitation. Even among those with internet access, the relationship between health literacy and patient portal use persisted (OR 1.4, 95% CI 1.2 to 1.8). Diabetes patients reporting limited health literacy were less likely to both access and navigate an internet-based patient portal than those with adequate health literacy. Although the internet has potential to greatly expand the capacity and reach of health care systems, current use patterns suggest that, in the absence of participatory design efforts involving those with limited health literacy, those most at risk for poor diabetes health outcomes will fall further behind if health systems increasingly rely on internet-based services.

Almost half of adults in the United States have limited health literacy (Institute of Medicine, 2004). Compared with those with adequate health literacy, patients with limited health literacy experience disparities in health and health care access (Sudore et al., 2006). They have poorer knowledge about their disease processes (Dewalt, Berkman, Sheridan, Lohr, & Pignone, 2004) medication regimens (Davis et al., 2006; Fang, Machtinger, Wang, & Schillinger, 2006; Kripalani et al., 2006; Wolf et al., 2005) and methods for managing their disease (Cavanaugh et al., 2008; Paasche-Orlow et al., 2005; Rothman et al., 2006; Williams, Baker, Honig, Lee, & Nowlan, 1998). Limited health literacy (HL) is relatively common among patients with type 2 diabetes (Morris, MacLean, & Littenberg, 2006; Sarkar, Fisher, & Schillinger, 2006; Schillinger, Barton, Karter, Wang, & Adler, 2006; Schillinger, Bindman, Wang, Stewart, & Piette, 2004; Schillinger et al., 2002; Schillinger et al., 2003; Williams, Baker, Parker, & Nurss, 1998) and may reduce the effectiveness of offered health services, thereby contributing to poorer diabetes outcomes (Cavanaugh et al., 2008; Schillinger et al., 2002).

Increasingly, the internet is being utilized in managing outpatients with diabetes, for self-management support and for routine interactions with the health care system, such as making appointments and obtaining medication refills (Armstrong & Powell, 2008; Grant et al., 2006; Kahn, Aulakh, & Bosworth, 2009; Mulvaney, Rothman, Wallston, Lybarger, & Dietrich, 2009). Universal use of health information technology is a central tenet of U.S. health care reform (Health IT Policy Committee, 2009). Disparities exist in use of computers and the internet by both race/ethnicity and educational attainment: the oft-cited “digital divide” (Hsu et al., 2005; Lenhart, Rainie, Fox, Horrigan, & Spooner, 2000).

It is unknown however, whether those with limited health literacy are less likely to use the internet, in particular, for health-related tasks. An internet-based patient portal has the potential to lower health literacy demands, through use of audio,

video, and graphics, but there also may be less computer access and difficulties with computer navigation for those with limited health literacy (Hernandez, 2009; Institute of Medicine, 2009). Because innovations in health care can actually exacerbate health disparities, as more advantaged populations experience disproportionately greater benefit from health innovations (Glied & Lleras-Muney, 2008; Fremont, Wickstrom, & Escarce, 2003), we hypothesized that health-care-related internet use would be lower among those with limited health literacy.

Therefore, we examined whether use of an internet-based patient portal among a well characterized cohort of English-speaking adult patients with diabetes differed between those who report limited health literacy versus those who do not.

Methods

Study Population

The Diabetes Study of Northern California (DISTANCE) enrolled patients from the Kaiser Permanente Northern California (KPNC) Diabetes Registry, a large, ethnically diverse and well characterized population with diabetes. KPNC is a fully integrated health care delivery system that provides comprehensive medical care to over 3 million members (30% of the entire Northern California population). Except for the extremes of income, the demographic characteristics of KPNC's patient population are similar to those of the overall population of Northern California (Krieger, 1992).

The overarching aim of the DISTANCE study (<http://distancesurvey.org>) was to investigate ethnic and educational disparities in diabetes-related behaviors, processes of care, and health outcomes. The survey methods and cohort profile have been described previously (Moffet et al., 2008). Briefly, three modes of the DISTANCE Survey were offered to all patients in the sample: self-administered written questionnaire, web-based survey, or computer-assisted telephone interview (CATI) with interviews conducted in English, Spanish, Cantonese, Mandarin, or Tagalog. The extensive survey was conducted among an ethnically stratified, random sample of 40,735 diabetes patients, aged 30 to 75 years at baseline, of known (Caucasian, African-American, Latino, Asian) and unknown ethnicity. We asked participants to report age, gender, educational attainment, and race/ethnicity.

The surveys had a 62% response rate (AAPOR, 2009), completed by 20,188 respondents. Respondents were of primarily (78%) minority (non-White) race/ethnicity and varied widely in clinical and behavioral profiles, as well as education, income, wealth, occupation, nativity and neighborhood characteristics. For this analysis, we included only respondents who spoke and read English, had adequate vision (not legally blind), and were members throughout the study period, January–December 2006. We obtained data on usage of the internet-based patient portal from the electronic member database, January to December, 2006. This study was approved by the institutional review board at Kaiser Foundation Research Institute.

“KP.org”: The Internet Patient Portal

The internet patient portal began use in Northern California in 1999, although it offered only minimal services initially. The patient portal is offered to all members

and includes a public website with health promotion information and information on obtaining health insurance. Key features include laboratory test results with interpretation and email communication with physicians (both available since November 2005). It also permits the clinical transactions of refilling medications (available since January 2001) and making medical appointments (available since October 2002). In order to use the system, participants first had to register on a secure website (kp.org). KPNC then sent each “registered” participant a mailed letter with his/her default password. Participants needed to have computer and internet access in order to register for the patient portal. Once participants logged in with this default password, they changed the default to their own password and the account was considered “active.”

KP publicizes the patient portal through television, radio, print, and internet advertising, as part of subscriber information, in stand-alone promotions, and with presentations to insurance purchasers. KPNC does not offer computer or internet training for those who wish to use the patient portal, but internal staff are trained to help users who call for assistance.

Outcomes

Previous studies have used various definitions for use of a patient portal (Kaelber & Pan, 2008; Roblin, Houston, Allison, Joski, & Becker, 2009). We aimed to characterize each incremental step in using the patient portal. We report the proportion of study participants who registered for the patient portal via internet, activated their accounts, signed on to the patient portal, and used each function: viewing laboratory test results; sending email to providers; requesting medication refills; and making medical appointments. We compared those who performed each function one or more times with those who never used it.

Exposure

To obtain self-reported HL, we employed a slightly modified version of an instrument validated against direct HL measures (Chew, Bradley, & Boyko, 2004; Chew et al., 2008) in patients with diabetes and across a variety of research settings (U. Sarkar et al., 2008; Wallace et al., 2007; Wallace, Rogers, Roskos, Holiday, & Weiss, 2006). This instrument asks about problems due to reading, understanding, and filling out forms, not due to poor vision: (a) “How often do you have problems learning about your medical condition because of difficulty understanding written information?”; (b) “How confident are you filling out medical forms by yourself?”; (c) “How often do you have someone like a family member, friend, hospital or clinic worker or caregiver, help you read Kaiser health plan materials (such as written information about your health or care you are offered)?” In keeping with prior studies, we dichotomized Likert responses into ever having difficulties versus never having difficulties (U. Sarkar et al., 2010). We considered “don’t know” responses as missing. Each question was analyzed separately, as recommended by the instrument’s author (Chew et al., 2004, 2008). We also created a summative scale by adding the responses to the 3 items. The resulting scale values ranged from 3 to 15, with higher values representing better health literacy. A value of 15 represents reporting no difficulties with any of the three questions above, whereas 3 represents always having difficulties in all three questions above. We have previously used

these questions among diverse diabetes patients, and found that they are not only associated with direct health literacy measurement (concurrent validity), but also with a patient's reported communication needs, incidence of hypoglycemia, and desire for self-management support (i.e., predictive validity) (U. Sarkar et al., 2008a, 2008b).

Analysis

We calculated summary statistics for the outcomes by health literacy, for each individual question and overall. Based on the distribution of the overall health literacy scale, we dichotomized such that any problems (a value of ≤ 14) with health literacy was considered "limited" versus reporting no problems, which we characterized as "adequate" (scale = 15). We then performed several multivariate analyses. First, we evaluated the independent association of self-reported health literacy with *signing on* to the on-line portal. We chose to model signing on because signing on with one's own password is the *final step prior* to performing any of the health-related functions and is therefore most indicative of the digital divide. For ease of interpretation, we used the dichotomized version of the health literacy scale, comparing those with any reported difficulty with health literacy to those reporting no difficulty. We created multivariate models, adjusted for age, gender, race/ethnicity, educational attainment, and household income (Model 1) and with health literacy (Model 2). We include models without and with health literacy to examine how associations with race/ethnicity and educational attainment changed. First, we report associations for the entire study sample, and then restricted to those who registered for the patient portal, as a proxy for computer access. Second, we estimated the independent association (adjusted as above for age, gender race/ethnicity, educational attainment, and household income) between reported health literacy and use of individual patient portal functions (labs view, medication refills, email to providers, and medical appointments), to further illuminate the role of health literacy in these specific computer navigation tasks.

Results

We include 14,102 participants in this analysis (Table 1). The sample was ethnically diverse: 3957 (28%) were non-Hispanic White, 1923 (14%) Latino, 2899 (21%) African-American, 1253 (9%) Asian, 1624 (12%) Filipino, and 2446 (17%) multi-racial/other ethnicity. Overall, 6099 (62%) reported some limitation in health literacy using the three-item scale; 43% reported problems learning about health due to reading difficulties, 28% reported needing help reading health related materials, and 19% were not confident with health care forms.

During the study period, 5671 (40%) registered via the internet for the patient portal. Of these registered users, 4311 (76%) logged in with their default password, and thereby became active users, and 3922 (69%), signed on to the patient portal one or more times using their own password. The most frequent type of patient portal use was viewing laboratory results (2990 participants), followed by requesting medication refills (2132 participants), sending email messages to a KP provider (2093 participants), and making a medical appointment (835 participants).

For all functions, those reporting lack of confidence with medical forms represented a disproportionately small fraction of users (Figure 1A), and this pattern was

Table 1. Participant characteristics

Characteristic	N (%) or Mean (SD)
Age (y)	59
30–39	578 (4)
40–49	2065 (15)
50–59	4604 (33)
60–69	4519 (32)
≥70	2336 (17)
Female	6885 (49)
Race/Ethnicity	
African-American	2899 (21)
Non-Hispanic White	3957 (28)
Latino/a	1923 (14)
Asian	1253 (9)
Filipino	1624 (12)
Other/Mixed	2446 (17)
HbA1c%	7.59
Diabetes duration, yrs	10.12 (9)
Educational attainment	
No degree	1397 (10)
HS or GED	4099 (30)
Some college	3739 (27)
College grad/post grad	4581 (33)
Income	
Less than \$14,999	2052 (6)
\$15,000 to \$24,999	2885 (6)
\$25,000 to \$34,999	3755 (9)
\$35,000 to \$64,999	5069 (26)
\$65,000 and greater	8784 (38)
Problems learning	4288 (43)
Need help reading	2790 (28)
Not confident with forms	1923 (19)
Any health literacy limitation	6099 (62)

similar with the other two health literacy items (not shown). When we stratified the sample into those with and without self-reported literacy limitations, we found a lower proportion of portal use across all function for those with any literacy limitation (Figure 1B).

For the overall study population, African-America, Latino, and Filipino race/ethnicities were associated with increased risk of not signing on to the patient portal. We also observed an educational gradient, such that those with lower educational attainment were less likely to sign on (Table 2). When we added health literacy to the model, the relationship between education and signing on persisted (Table 2), and self-reported limitation in health literacy was associated with higher odds of never signing on (OR 1.7, 95% CI 1.4 to 1.9). When we restricted the analysis to those who had computer access, as measured by registration for the patient portal, we found the patterns of racial/ ethnic associations with use were similar, but the

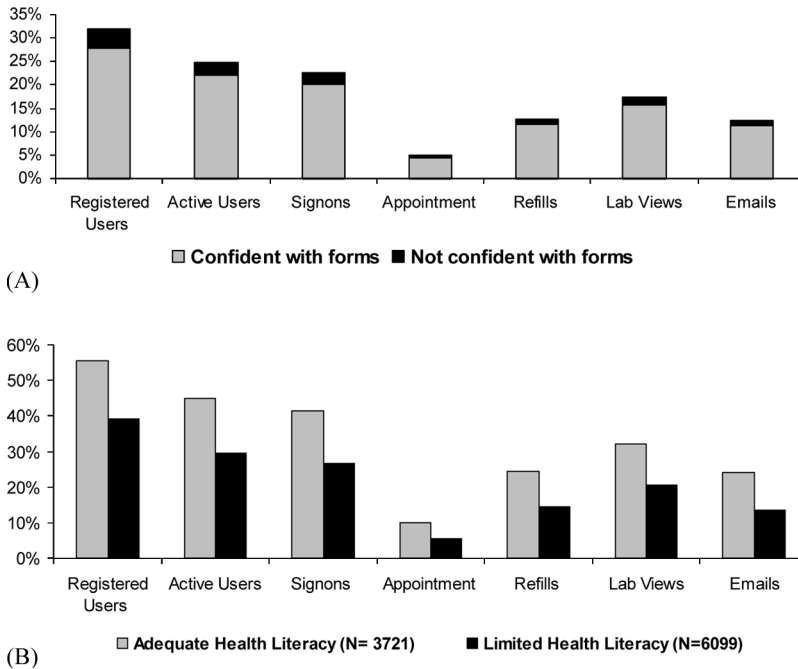


Figure 1. (A) Overall proportion of total population who used each patient portal function, those with confidence vs. those with difficulties with medical forms (N = 14,102; for difference between those with and without confidence with forms, p for all $<.01$). (B) Proportion of subjects with adequate health literacy (N = 3,721) and limited health (N = 6,099) who performed each portal function (for difference between those with and without limited health literacy, p for all $<.01$).

magnitude of the association between educational attainment and patient portal use was much reduced and, largely, no longer significant (Table 2). However, when added to this model among registered users, limited health literacy remained significantly associated with not using the patient portal (OR 1.4, 95% CI 1.2 to 1.8).

Finally, we investigated independent associations of health literacy on each portal function, among those with computer access (registered users). We found that across each function, those reporting limited health literacy were consistently less likely to complete each patient portal function (Table 3). In contrast, educational attainment was much less strongly associated with successful completion of each function, although it remained significantly associated with sending emails to providers (Table 3).

Discussion

To our knowledge, this is the first study to assess real-world use of an industry-leading patient portal in a large, ethnically, culturally, socioeconomically, and educationally diverse sample of diabetes patients with a range of self-reported health literacy skills. We found clear racial/ethnic disparities in patient portal use, as have been previously documented (Hsu et al., 2005), and differences by educational attainment as well. As expected, we found much lower rates of patient

Table 2. Adjusted odds ratios for never signing on, among all participants and restricted to registered users

Characteristic	Adjusted odd ratios for never signed on			
	Entire population [†]		Registered users [§]	
	*Model 1	[†] Model 2	*Model 1	[†] Model 2
Age** (years)				
40–49	0.93 (0.67–1.3)	1.0 (0.77–1.3)	0.86 (0.57–1.3)	0.83 (0.58–1.2)
50–59	0.96 (0.71–1.3)	1.1 (0.82–1.4)	0.70 (0.46–1.0)	0.69 (0.49–0.97)
60–69	1.1 (0.84–1.6)	1.3 (0.98–1.6)	0.61 (0.40–0.93)	0.59 (0.41–0.84)
70+	1.6 (1.1–2.2)	1.8 (1.4–2.4)	0.57 (0.35–0.94)	0.55 (0.36–0.84)
Female	1.1 (0.98–1.3)	1.1 (0.94–1.2)	1.3 (1.0–1.6)	1.2 (1.0–1.4)
Race/ Ethnicity ^{††}				
African American	2.4 (2.1–2.8)	2.6 (2.3–3.0)	1.7 (1.4–2.1)	1.8 (1.5–2.1)
Latino	2.3 (1.9–2.8)	2.3 (2.0–2.7)	1.8 (1.4–2.3)	1.8 (1.4–2.2)
Asian	0.99 (0.82–1.2)	1.1 (0.95–1.3)	0.77 (0.57–1.0)	0.86 (0.66–1.1)
Filipino	2.4 (2.0–3.0)	3.1 (2.6–3.6)	1.3 (0.98–1.8)	1.6 (1.2–2.1)
Multiracial/ Other	1.6 (1.4–2.0)	1.6 (1.4–1.9)	1.4 (1.0–1.8)	1.4 (1.1–1.8)
Education ^{‡‡}				
No degree	1.5 (1.1–2.0)	1.8 (1.4–2.2)	0.92 (0.60–1.4)	1.1 (0.76–1.6)
High school/ GED	1.6 (1.3–1.9)	1.7 (1.5–2.0)	1.3 (1.0–1.7)	1.4 (1.1–1.7)
Some College	1.3 (1.1–1.5)	1.4 (1.2–1.6)	0.99 (0.77–1.3)	1.1 (0.90–1.4)
Income ^{§§}				
Less than \$14,999	2.7 (1.9–3.9)	2.8 (2.0–3.9)	1.6 (0.92–2.7)	1.7 (1.1–2.7)
\$15,000 to \$24,999	1.9 (1.4–2.6)	1.9 (1.5–2.5)	1.1 (0.63–1.8)	1.0 (0.65–1.6)
\$25,000 to \$34,999	1.5 (1.2–1.9)	1.7 (1.4–2.1)	0.82 (0.56–1.2)	0.90 (0.64–1.3)
\$35,000 to \$64,999	1.4 (1.2–1.7)	1.4 (1.2–1.6)	1.2 (0.94–1.5)	1.1 (0.93–1.4)
HL Scale		1.7 (1.4–1.9)		1.4 (1.2–1.8)

*Model 1 Adjusted for age, gender, race, educational attainment.

[†]Model 2 Adjusted for age, gender, race, and educational attainment, and health literacy.[‡]N for model = 9666.[§]N for model = 4407.

**Reference: 30–39 years old.

^{††}Reference: non-Hispanic Whites.^{‡‡}Reference: college graduate or more education.^{§§}Reference: \$65,000 and greater.

portal use among those reporting limited compared to adequate health literacy. The lower registration rates among those with limited health literacy underscores existing concerns about lack of computer/internet access among those with limited health literacy, i.e., literacy–digital divide (Institute of Medicine, 2009; Lenhart et al.,

Table 3. Social disparities in Patient Portal use, for each function (Registered users only) (N = 5671)

Characteristic	Never used labs view	Never used med refills	Never used email	Never used appointment
Age* (years)				
40–49	0.91 (0.61–1.4)	0.54 (0.36–0.80)	0.78 (0.51–1.2)	0.46 (0.27–0.80)
50–59	0.77 (0.52–1.1)	0.52 (0.36–0.75)	0.73 (0.49–1.1)	0.46 (0.27–0.77)
60–69	0.67 (0.45–1.0)	0.53 (0.36–0.78)	0.69 (0.46–1.0)	0.53 (0.31–0.90)
70+	0.58 (0.36–0.91)	0.68 (0.43–1.1)	0.85 (0.54–1.4)	0.49 (0.26–0.91)
Female†	1.1 (0.94–1.3)	1.4 (1.2–1.7)	1.0 (0.85–1.2)	0.73 (0.57–0.93)
Race/Ethnicity‡				
African American	1.8 (1.5–2.2)	1.8 (1.4–2.2)	1.6 (1.3–2.0)	1.5 (1.1–2.0)
Latino	1.7 (1.3–2.2)	1.6 (1.3–2.2)	1.7 (1.3–2.2)	1.6 (1.1–2.2)
Asian	0.79 (0.61–1.0)	0.87 (0.67–1.1)	1.1 (0.82–1.4)	0.85 (0.60–1.2)
Filipino	1.4 (1.0–1.8)	2.0 (1.5–2.7)	2.0 (1.5–2.6)	1.6 (1.0–2.3)
Multiracial/Other	1.4 (1.0–1.8)	1.5 (1.1–1.9)	1.4 (1.1–1.8)	1.4 (0.95–2.0)
Education§				
No degree	0.79 (0.54–1.2)	0.92 (0.63–1.3)	1.3 (0.90–1.9)	0.97 (0.59–1.6)
High school or test equivalent	1.2 (0.98–1.6)	1.1 (0.87–1.4)	1.4 (1.1–1.8)	1.4 (1.0–2.0)
Some College	0.95 (0.75–1.2)	1.0 (0.80–1.3)	1.1 (0.85–1.4)	0.98 (0.72–1.3)
HL Scale	1.3 (1.1–1.6)	1.6 (1.3–1.9)	1.4 (1.1–1.7)	1.3 (1.0–1.7)
Income**				
Less than \$14,999	1.3 (0.78–2.2)	1.4 (0.80–2.5)	1.9 (1.0–3.4)	2.2 (0.8–6.0)
\$15,000 to \$24,999	1.7 (1.0–2.7)	0.88 (0.55–1.4)	0.85 (0.54–1.3)	1.6 (0.81–3.2)
\$25,000 to \$34,999	1.3 (0.89–1.8)	0.89 (0.62–1.3)	1.5 (1.0–2.1)	1.5 (0.91–2.4)
\$35,000 to \$64,999	1.2 (0.97–1.5)	0.89 (0.72–1.1)	1.0 (0.84–1.3)	1.2 (0.92–1.6)

*Reference: 30–39 years old.

†Reference: Male.

‡Reference: Caucasian.

§Reference: College Graduate or more.

**Reference: \$65,000 and greater.

2000). Importantly, the disparities in use of the patient portal by health literacy, race/ethnicity, and education mirror the well documented disparities in diabetes outcomes (Agency for Healthcare Research and Quality, 2004). As such, this represents a significant public health concern, especially as U.S. health policy increasingly emphasizes health information technology, potentially at the expense of alternative modes of service delivery. The inverse care law states that health care innovations disproportionately benefit healthier individuals (Hart, 1971; Schillinger, 2007) and thus exacerbate health disparities. Our findings serve as yet another manifestation of that phenomenon.

Even after we attempted to control broadly for computer/internet access, by including models involving only those who completed the internet-based registration process, we found that those with limited health literacy were less likely to activate their patient portal account, sign in using their personal login and password, and to use any of the functions. This suggests that those with limited health literacy may have difficulties with *navigation* of an internet-based patient portal, in addition to having lower rates of access to computer/internet. Moreover, we found that the function most likely to be used, across all literacy levels, was the “Labs View” function, which is a relatively passive use function, a vehicle for delivering information, rather than more active and even interactive tasks like making an appointment or emailing one’s provider. This also suggests that navigation of more complex internet-based tasks (e.g., diabetes self-management instructions) constitutes a barrier, as others have suggested (Norman & Skinner, 2006). Importantly, in our sample, among those with computer access, self-reported health literacy was more strongly and consistently associated with lack of patient portal use than was lower educational attainment.

There are a number of potential mechanisms to explain our findings. First, those with limited health literacy may not be aware that the online patient portal exists; tailored (literacy level appropriate) promotion of online patient portal use in this group may be needed. Second, those with limited health literacy may not be empowered or motivated to learn to use an online patient portal. For instance, inadequate social/family support for skill-building, culturally dependent health beliefs that do not promote patient activation, and lack of trust in the medical system may all influence use of an internet-based patient portal. Specific social messaging and other outreach efforts could combat these factors. Third, a major barrier to online patient portal use is internet access, which includes absent or limited computer access, lack of computer/internet training, and competing time demands. Increasing access to internet, computers, and training, particularly within health care settings, may reduce access barriers. Fourth, those with limited health literacy may find internet-based patient portals difficult to navigate. This can be addressed with specific, hands-on training, and design features that improve ease of navigation and are appropriate for limited-health-literacy populations, such as video, audio, and graphical information.

Study strengths include a large, diverse population with uniform access to care, and detailed assessments of use of an internet-based patient portal, among well characterized diabetes patients, within a real world setting. Nevertheless, this study has several limitations. First, although KPNC’s population is diverse, results may not generalize to the uninsured, those cared for in other systems, or different patient portals. Second, Kaiser Permanente (KP) has a much more robust and well established internet-based patient portal than most other U.S. health care delivery

settings, and, as such, our finding may overestimate patient portal use compared with other settings. However, we anticipate that as internet-based patient portal become more the standard, these issues will emerge in other settings. Third, we did not directly measure participants' computer access, although an internal survey of KPNC members suggests that 90% of members aged 25 to 64 years and 50% of members aged 65 to 79 years have internet/computer access (Gordon, 2009). As another proxy for access, we inferred that those who registered on-line had some level of access to the internet. We acknowledge that a continuum of internet access exists; we could not capture extent of access, or access barriers, with the current data. Fourth, not all participants answered every question in this lengthy survey (184 questions, 52 pages). Nevertheless, this remains the largest observational study to date of internet-based patient portal use. Fifth, the nature of study design precluded our being able to directly measure health literacy in this sample; however, we used validated, widely used items to estimate health literacy (Chew et al., 2004; Chew et al., 2008; U. Sarkar et al., 2008; Wallace et al., 2006). Sixth, we did not assess the usability of the online patient portal through direct observation, user satisfaction evaluations, or other methods. Finally, it is possible that those with diabetes may be more likely to use an internet-based patient portal because of increased health care and self-management needs; these results may not apply to healthier adults. However, diabetes is common and costly; therefore, understanding how those with diabetes adapt to efficient new technologies is a public health and policy priority.

Future research should examine the possible links between patient portal use and processes of care, such as visit attendance, visit interval, attendance at screening such as ophthalmology, completion of ordered laboratory testing, and possibly clinical outcomes such as hemoglobin A1c and blood pressure. Moreover, patient portal usage data may be useful to clinicians and caregivers, perhaps as an indicator of relative internet navigational limitations.

Our study has important public health and policy implications. First, ensuring universal internet and computer access will become more important than ever. As services migrate to the internet, those most at risk for poor diabetes health outcomes are at risk of falling further behind as health systems increasingly rely on patient portal health service functions and limit the alternative modes of access and communication. Second, improving the usability of internet-based patient portals, such that those with limited health literacy can navigate them effectively, is critical to realizing health benefits. The internet has potential, via use of audio, graphic, video, and multiple languages, to greatly expand the capacity and reach of health care systems (Institute of Medicine, 2009). However, in the real world, that potential has yet to be realized. Barriers to internet-based health care services require improved technology access as well as tailoring of design and services to reach those with limited health literacy.

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